

UPPER MAESTRICHTIAN PLANKTONIC FORAMINIFERA FROM GALICIA BANK, WEST OF SPAIN

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ABSTRACT. An upper Maestrichtian assemblage of planktonic foraminifera is described from a sample of chalk dredged from Galicia Bank, a non-magnetic seamount off the west coast of Spain. The presence of post-Maestrichtian planktonic species in the sample is attributed to the burrowing of mud-feeding organisms. It is suggested that the very high percentage of planktonic individuals in the upper Maestrichtian limestone of Galicia Bank is a product of depth and proximity to an open oceanic environment during deposition.

THIS paper describes the members of an assemblage of planktonic foraminifera which were used to date a fragment of soft chalky limestone (Funnell 1964) dredged from the upper slopes of the Galicia Bank, a flat-topped non-magnetic seamount off the west coast of Spain. The sample D. 3804.1, which was dredged from a depth of 650–700 m. at 42° 36' N., 11° 35' W. (station D. 3804), is one of a series of samples obtained from the slopes of the seamount during the summer of 1958 (Black *et al.* 1964).

The assemblage contains species and subspecies diagnostic of the upper Maestrichtian, and equates with the *Abathomphalus mayaroensis* zone of Trinidad (Bolli 1957), the *Globotruncana contusa* zone of Tunisia (Dalbiez 1955), the KF zone of Upper Austria (Wille-Janoschek 1966), and the *Pseudotextularia elegans* zone of southern Scandinavia (Berggren 1962), which are the highest Maestrichtian zones in their respective areas.

In a count of 507 specimens, 95% were planktonic (including 22% heterohelicids), 5% benthonic, and 0.2% post-Maestrichtian contaminants.

The contaminants, which include planktonic species of mid-Tertiary and upper Tertiary to Recent origin, were probably introduced into the samples via burrows or borings (Funnell 1964). Black (1964) attributed a mixed assemblage of Cretaceous and Tertiary coccoliths in the same sample to the burrowing of mud-feeding organisms.

Investigations of the ratio of planktonic to benthonic individuals in Recent sediments by Smith (1955), Grimsdale and Morkhoven (1955), and Hay (1960) suggest that, despite variations attributable to local conditions, a general relationship exists between increasing proportion of planktonic individuals, depth, and proximity to the open oceans. Grimsdale and Morkhoven considered sediments containing over 98% planktonic individuals as indicative of a depth of deposition of at least 700 m. Hay (1960) suggested that the upper Cretaceous Mendez and Palaeocene Velasco formations of the Tampico embayment, whose faunas both contain 90% or more planktonic species, were deposited 'in waters at least 250 and probably more than 500 m deep'.

The paucity of data concerning conditions in the Upper Cretaceous, and the debatable procedure of including the heterohelicids in planktonic counts, suggests that the planktonic/benthonic ratio provides at the most an approximation of the depth of deposition during this period (see Funnell 1967, pp. 339–40). Nevertheless the high ratio of planktonic species (95% including the heterohelicids; 73% excluding the heterohelicids) in

the upper Maestrichtian limestone of the Galicia Bank is most probably indicative of an open oceanic environment, and is not at variance with the depth of deposition from which the sample was dredged.

The line illustrations were prepared by Mrs. J. K. Friend (née Bean) in 1964; the electron micrographs were taken by the Cambridge Instrument Company Ltd. on a Stereoscan II in 1967. In all cases except one the same specimens were used on both occasions. 'Hypotype' and illustrated specimens have been deposited in the Sedgwick Museum, Cambridge, together with complete synonymies and bibliography of the species described.

Acknowledgements. Mr. M. J. Fisher kindly assisted in bringing the synonymies up to date. The work was supported in part by a N.E.R.C. research grant.

SYSTEMATIC DESCRIPTIONS

Family HETEROHELICIDAE Cushman 1927

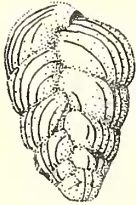
Subfamily HETEROHELICINAE Cushman 1927

Genus HETEROHELIX Ehrenberg 1843

Heterohelix globulosa (Ehrenberg)

Plate 1, figs. 1, 2; text-fig. 1

- 1834 *Textilaria globulosa* Ehrenberg, p. 135, pl. 4, fig. 4 (*vide* Ellis and Messina 1940 et seq.).
 1951 *Guembelina globulosa* (Ehrenberg); Visser, p. 254, pl. 8, fig. 8.
 1960 *Guembelina globulosa* (Reuss); Hofker, p. 224, fig. 18, p. 225, fig. 39.
 1961 *Heterohelix globulosa* (Ehrenberg); Said and Kerdany, p. 331, pl. 2, fig. 1.
 1966 *Heterohelix globulosa* (Ehrenberg); Barr, p. 503, pl. 78, figs. 5, 6.
 1966 *Guembelina globulosa* (Ehrenberg); Hofker, p. 107, pl. 10, fig. 110.
 1966 *Guembelina cf. globulosa* (Ehrenberg); Hofker, p. 170, pl. 29, fig. 63.
 1966 *Heterohelix globulosa* (Ehrenberg); Lehmann, p. 314, pl. 2, fig. 9.
 ? 1966 *Heterohelix globulosa* (Ehrenberg); Wille-Janoschek, pp. 148, 149, 151, no fig.



a



TEXT-FIG. 1. *Heterohelix globulosa* (Ehrenberg),
 b (a) lateral view, (b) apertural view; No. 1165, $\times 100$.

Description. In the specimens examined the test is composed of 15 chambers. The first 4 or 5 are small and coiled about the proloculus, later chambers are biserially arranged and increase in size and globosity, a development which is most apparent in the last 4 chambers. The chamber surfaces are ornamented with fine longitudinal costae; pores are confined to the intercostate surfaces. The aperture is simple, slit-like, interiomarginal.

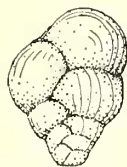
Stratigraphical distribution. *H. globulosa* is recorded from the Santonian (Küpper 1956) to upper Maestrichtian.

Geographical distribution. A widely distributed species ranging from approximately 55° N. (Vigsö and Rödvig, Denmark; Hofker 1960) to 25° S. (Carnarvon Basin, W. Australia; Belford 1960). Within these latitudes it is recorded from the Pacific Ocean (Hamilton 1953), California (Martin 1964), the U.S. Gulf Coast (Cushman 1946), Mexico (Olvera 1959), Cuba (van Wessema 1943), northern Europe (Visser 1951), the circum-Mediterranean, and India (Nagappa 1959).

Heterohelix striata (Ehrenberg)

Plate 1, figs. 3, 4; text-fig. 2

- 1839 *Textilaria striata* Ehrenberg, p. 135, pl. 4, figs. 1, 2, 3 (*vide* Ellis and Messina 1940 et seq.).
 1946 *Guembelina striata* (Ehrenberg); Cushman, p. 104, pl. 45, figs. 4, 5.
 1953 *Pseudoguembelina striata* (Ehrenberg); Brönnimann and Brown, p. 154, fig. 6.
 1959 *Heterohelix striata* (Ehrenberg); Olvera, pp. 71, 72, pl. 2, figs. 4, 8.
 1964 *Heterohelix striata* (Ehrenberg); Martin, p. 85, pl. 11, fig. 1.
 1964 *Pseudoguembelina striata* (Ehrenberg); Said and Sabry, p. 394, pl. 3, fig. 21.
 ? 1966 *Heterohelix striata* (Ehrenberg); Wille-Janoschek, pp. 148, 149, 151, no fig.
 1966 *Guembelina striata* (Ehrenberg); Hofker, pp. 31, 64, 79, 150, 189, 318; pl. 3, fig. 68; pl. 10, fig. 109; pl. 14, figs. 80, 81; pl. 23, figs. 116, 117; pl. 33, fig. 76; pl. 34, fig. 105; pl. 73, fig. 166.
 1966 *Heterohelix striata* (Ehrenberg); Lehmann, p. 315, pl. 2, fig. 8.



a



b

TEXT-FIG. 2. *Heterohelix striata* (Ehrenberg), (a) lateral view, (b) apertural view; No. 1164, $\times 100$.

Description. In the specimens examined 10–12, more or less globular, biserially arranged chambers increase gradually in size, and are ornamented with fine longitudinal costae which do not extend across the sutures. The aperture is simple, lunate, interiomarginal; pores are confined to the intercostate surfaces.

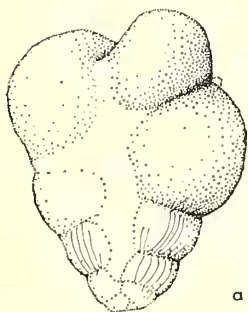
Stratigraphical distribution. Common in the Maestrichtian but also occurs in the upper Campanian (Wille-Janoschek 1966).

Geographical distribution. *H. striata* is geographically widespread. It ranges from approximately 57° N. (Kjölby Gaard, Denmark; Berggren 1960) to 25° S. (Carnarvon Basin, West Australia; Belford 1960); between these latitudes it is recorded from the Pacific Ocean (Hamilton 1953), California (Martin 1964), the U.S. Gulf Coast (Cushman 1946), Mexico (Olvera 1959), Cuba (Brönnimann and Brown 1953), Puerto Rico (Pessagno 1960), northern Europe, the circum-Mediterranean, and Pakistan (Nagappa 1960).

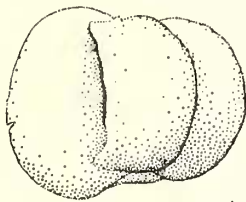
Heterohelix ultimatunida (White)

Plate 1, figs. 5, 6; text-fig. 3

- 1929 *Guembelina ultimatunida* White, p. 39, pl. 4, fig. 13.
 1959 *Heterohelix ultimatunida* (White); Olvera, pp. 72, 73, pl. 1, fig. 16.



a



b

TEXT-FIG. 3. *Heterohelix ultimatunida* (White), (a) lateral view, (b) apertural view; No. 1166, $\times 100$.

Description. The specimens examined consist of about 10 biserially arranged chambers; the first 6 are radially costate and increase gradually in size and globosity, the last 4 chambers are large, globose, smooth or finely costate; the ultimate chamber is smaller than the penultimate. The aperture is large, simple, lunate, interiomarginal; pores are distributed between the costae.

Stratigraphical distribution. Campanian (Pessagno 1962) to upper Maestrichtian.

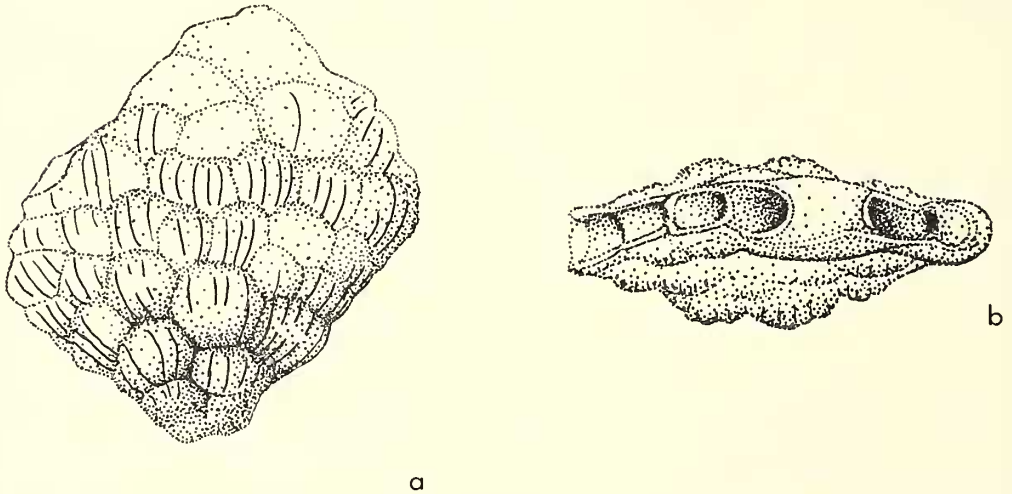
Geographical distribution. Records of this species are confined to the northern hemisphere between 50° N. (Glons, Belgium; Hofker 1958) and 18° N. (Puerto Rico; Pessagno 1962). Within these latitudes it is reported from the Pacific Ocean (Hamilton 1953), the U.S. Gulf Coast (Pessagno 1962), Mexico (Olvera 1959), Cuba (Voorwijk 1937), Germany (Hofker 1956b), and Egypt (Said and Kenawy 1956).

Genus PLANOGLOBULINA Cushman 1927

Planoglobulina acervulinoides (Egger)

Plate 1, figs. 7, 8; text-fig. 4

- 1900 *Gueubelina acervulinoides* Egger, p. 36, pl. 14, figs. 20–22 (*vide* Ellis and Messina 1940 et seq.).
 1926 *Pseudotextularia acervulinoides* (Egger); Cushman, p. 17, pl. 2, fig. 5.
 1927a *Planoglobulina acervulinoides* (Egger); Cushman, p. 158, pl. 27, fig. 3.
 1966 *Pseudotextularia acervulinoides* (Egger); Wille-Janoschek, pp. 99, 151, taf. 9, taf. 8, fig. 8.



TEXT-FIG. 4. *Planoglobulina acervulinoides* (Egger), (a) lateral view, (b) apertural view; No. 1158, $\times 100$.

EXPLANATION OF PLATE I

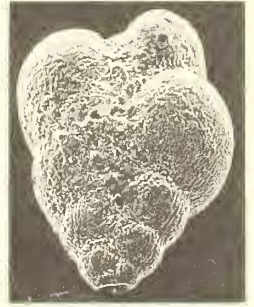
- Figs. 1–6. *Heterohelix* spp. 1, 2, *H. globulosa* (Ehrenberg), lateral and apertural views; No. 1165, $\times 150$. 3, 4, *H. striata* (Ehrenberg), lateral and apertural views; No. 1164, $\times 270$. 5, 6, *H. ultimata* (White), lateral and apertural views; No. 1166, $\times 95$.
 Figs. 7–8. *Planoglobulina acervulinoides* (Egger), lateral and apertural views; No. 1158, $\times 76$.
 Figs. 9–10. *Pseudotextularia elegans* (Rzehak), lateral and apertural views; No. 1159, $\times 68$.
 Figs. 11–12. *Pseudogueubelina costulata* (Cushman), lateral and apertural views; No. 1163, $\times 165$.



1



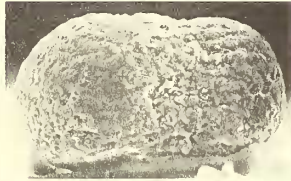
3



5



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6



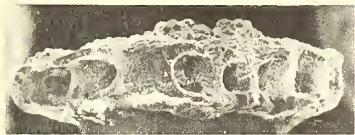
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9



11



8



10



12

Description. In the specimens examined the early chambers are biserially arranged, longitudinally costate, and increase gradually in size and globosity. Later chambers proliferate bilaterally; though initially inflated and strongly costate, they become less inflated, with weak and discontinuous costae. When observed the aperture is multiple; pores are arranged in single or double rows between the costae.

Stratigraphical distribution. *P. acervulinoides* is restricted to the Maestrichtian.

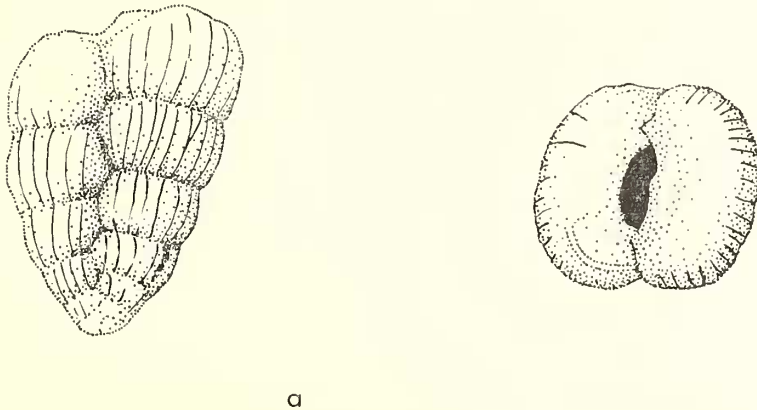
Geographical distribution. Records of this species are confined to the northern hemisphere between approximately 56° N. (Mors, Denmark; Berggren 1962) and 22° N. (Tampico, Mexico; Cushman 1926). Within these latitudes it has been recorded from Cuba (Voorwijk 1937), Alabama (Cushman 1946), New Jersey (Olsson 1960), northern Europe, and the circum-Mediterranean as far east as the Sinai Peninsula (Said and Kenawy 1956).

Genus PSEUDOTEXTULARIA Rzehak 1891

Pseudotextularia elegans (Rzehak)

Plate 1, figs. 9, 10; text-fig. 5

- 1888 *Cuneolina elegans* Rzehak, p. 191, no fig.
- 1929 *Guembelina elegans* (Rzehak); White, pp. 34, 35, pl. 4, fig. 8.
- 1946 *Guembelina plummerae* Loetterle; Cushman, p. 104, pl. 45, figs. 1-3.
- 1959 *Guembelina plummerae* Loetterle; Nagappa, p. 163, pl. 7, figs. 5-6.
- ? 1960 *Pseudotextularia elegans* (Rzehak); Berggren, pp. 185, 190, no fig.
- ? 1960 *Guembelina plummerae* Loetterle; Nagappa, p. 48, no fig.



TEXT-FIG. 5. *Pseudotextularia elegans* (Rzehak), (a) lateral view, (b) apertural view; No. 1159, $\times 100$.

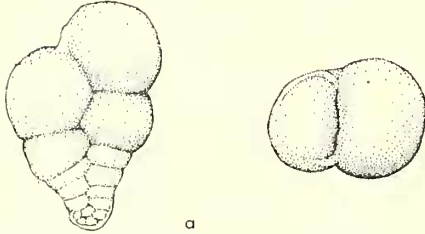
Description. The specimens examined have a more or less conical test, with biserially arranged, longitudinally costate chambers which increase gradually in size and globosity. The aperture is simple, lunate, interiomarginal; pores are confined to the surfaces between the costae.

Stratigraphical distribution. Santonian (Wille-Janoschek 1966) to upper Maestrichtian.

Geographical distribution. A widespread species ranging from approximately 57° N. (Kjölby Gaard, Denmark; Berggren 1960) to 16° S. (Madagascar; Lys 1960). Between these latitudes it is recorded from the Pacific Ocean (Hamilton 1953), the U.S. Gulf Coast (Cushman 1946), Mexico (White 1929), Cuba (van Wessem 1943), Puerto Rico (Pessagno 1960), the north Atlantic (Saito *et al.* 1966), northern Europe, the circum-Mediterranean, Pakistan, and India (Nagappa 1959, 1960).

GENUS *PSEUDOGUEMBELINA* Brönnimann and Brown 1953*Pseudoguembelina costulata* (Cushman)

Plate 1, figs. 11, 12; text-fig. 6

1938 *Guembelina costulata* Cushman, p. 16, pl. 3, figs. 7-9.1953 *Pseudoguembelina costulata* (Cushman); Brönnimann and Brown, pp. 153, 154, fig. 5.TEXT-FIG. 6. *Pseudoguembelina costulata* (Cushman),
b (a) lateral view, (b) apertural view; No. 1163, $\times 100$.

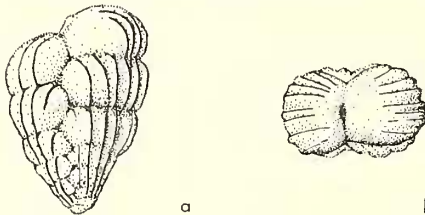
Description. In the specimens examined the test consists of 5-7 pairs of somewhat depressed, biserially arranged chambers which increase in size and are ornamented with fairly fine longitudinal costae, some of which extend across the sutures. The primary aperture is narrow, simple, lunate; accessory apertures are developed at the chamber bases on the central suture line.

Stratigraphical distribution. Campanian (Pessagno 1960) to Maestrichtian.

Geographical distribution. Records of this species are confined to the northern hemisphere between 34° N. (Arkansas; Cushman 1949) and 18° 15' N. (Puerto Rico; Pessagno 1960). Within these latitudes it has been reported from the Pacific Ocean (Hamilton 1953), Texas (Montanaro Gallitelli 1957), the U.S. Gulf Coast, Cuba (van Wessel 1943), and Egypt (Ansary and Fakhr 1958).

Pseudoguembelina excolata (Cushman)

Plate 2, figs. 1, 2; text-fig. 7

1926 *Guembelina excolata* Cushman, p. 20, pl. 2, fig. 9.1953 *Pseudoguembelina excolata* (Cushman); Brönnimann and Brown, p. 153, figs. 1-4.TEXT-FIG. 7. *Pseudoguembelina excolata*
(Cushman), (a) lateral view, (b) aper-
tural view; No. 1162, $\times 100$.

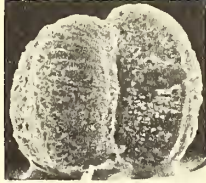
Description. In the specimens examined 4-7 pairs of chambers are arranged biserially; the initial 3 pairs increase gradually in size, later chambers increase rapidly in size and

EXPLANATION OF PLATE 2

- Figs. 1-2. *Pseudoguembelina excolata* (Cushman), lateral and apertural views; No. 1161, $\times 114$.
Figs. 3-4. *Racemiguembelina fructicosa* (Egger), lateral and apertural views; No. 1160, $\times 74$.
Figs. 5-10. *Abathomphalus* spp. 5-7, *A. mayaroensis* (Bolli), ventral, edge, and dorsal views; No. 1177, $\times 70$. 8-10, *A. intermedia* (Bolli), ventral, edge, and dorsal views; No. 1178, $\times 129$.
Figs. 11-13. *Globotruncana arca* (Cushman), ventral, edge, and dorsal views; No. 1167, $\times 71$.



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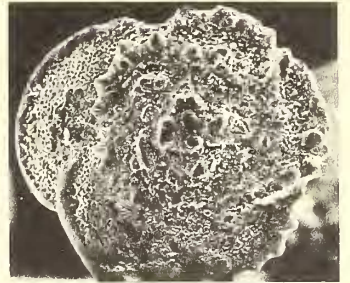
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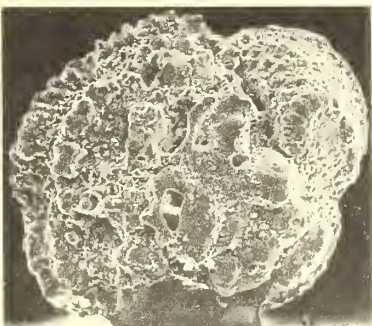
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9



10



11



12



13

degree of inflation. The chambers are coarsely costate, some costae extend across the sutures. The aperture is small, simple, lunate.

Stratigraphical distribution. Maestrichtian, but also occur in the upper Campanian (U. Taylor Formation, U.S. Gulf Coast; Cushman 1946).

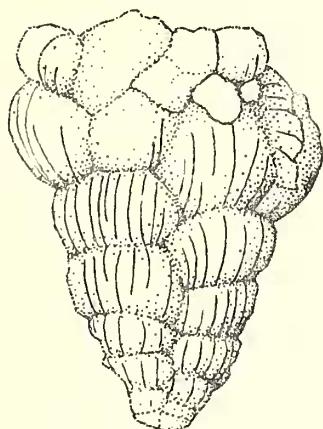
Geographical distribution. A widespread species in the northern hemisphere where it ranges from approximately 47° N. (Salzburg and Gams, Austria; Küpper 1956, Wicher 1956) to 19° N. (Pacific Ocean; Hamilton 1953). Between these latitudes it is recorded from the Tampico embayment, Mexico (Olvera 1959), Cuba (Brönnimann and Brown 1953), U.S. Gulf Coast (Cushman 1946) and New Jersey (Olsson 1960), and the circum-Mediterranean as far east as the Sinai Peninsula (Said and Kenawy 1956).

Genus *RACEMIGUEMBELINA* Montanaro Gallitelli 1957

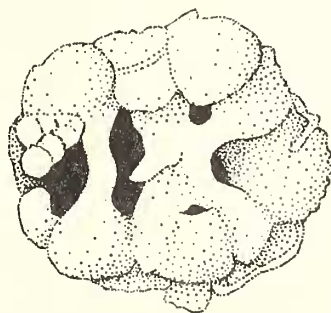
Racemiguembelina fructicosa (Egger)

Plate 2, figs. 3, 4; text-fig. 8

- 1895 *Pseudotextularia varians* Rzehak, pp. 217, 218, pl. 7, figs. 2, 3 (*vide* Ellis and Messina 1940 et seq.)
- 1900 *Guembelina fructicosa* Egger, p. 35, pl. 14, figs. 8, 9 (? 24, 25, 26) (*vide* Ellis and Messina 1940 et seq.).
- 1929 *Pseudotextularia varians* var. *mendezensis* White, p. 41, pl. 4, fig. 16.
- 1929 *Pseudotextularia varians* var. *textulariformis* White, p. 41, pl. 4, fig. 17.
- 1946 *Pseudotextularia varians* Rzehak; Cushman, p. 110, pl. 47, figs. 4-9.
- ? 1956 *Pseudotextularia varians* Rzehak; Wicher, p. 104, no fig.
- 1957 *Pseudotextularia varians* Rzehak; Hofker, pp. 422, 424, text-fig. 478a-l.
- 1957 *Racemiguembelina fructicosa* (Egger); Montanaro Gallitelli, pp. 142, 143, pl. 32, figs. 14, 15.
- 1958 *Pseudotextularia elegans* (Rzehak); Witwicka, p. 195, pl. 8, figs. 6, 7.
- 1959 *Pseudotextularia elegans* (Rzehak); Nagappa, p. 197, pl. 7, figs. 7, 8.
- 1960 *Pseudotextularia varians* Rzehak; Hofker, pp. 212, 216-17, 219, 220, 229-31, 237-9, 241, figs. 11, 42-44.
- 1960 *Pseudotextularia varians* Rzehak; Vinogradov, pl. 6, figs. 34, 35, tabs. 1, 2.



a



b

TEXT-FIG. 8. *Racemiguembelina fructicosa* (Egger), (a) lateral view, (b) apertural view; No. 1160, × 100.

Description. In the specimens examined the test is conical. Its chambers, which initially are biserially arranged, later proliferate, increase in size, and become more globular. The chambers are ornamented with coarse longitudinal costae. The aperture is multiple; apertures open into the lumen of the cone through a bridge of shell material which joins opposing chambers.

Stratigraphical distribution. Common in the Maestrichtian, but is also recorded from the upper Campanian (Kikoine 1948).

Geographical distribution. This species is widely distributed in the northern hemisphere. It ranges from approximately 57° N. (Vigsö, Denmark; Hofker 1960) to 19° 34' N., 171° 54' W. (Pacific Ocean; Hamilton 1953); within these latitudes it is recorded from the Tampico embayment, Mexico (White 1929), the U.S. Gulf Coast (Cushman 1946), Cuba (Voorwijk 1937), the north Atlantic (Saito *et al.* 1966), English Channel (Curry 1962), Germany (Hofker 1957), Austria (Wicher 1956), Poland (Witwicka 1958), Roumania (Vinogradov 1960), Egypt (Said and Kerdany 1961), and India (Nagappa 1959).

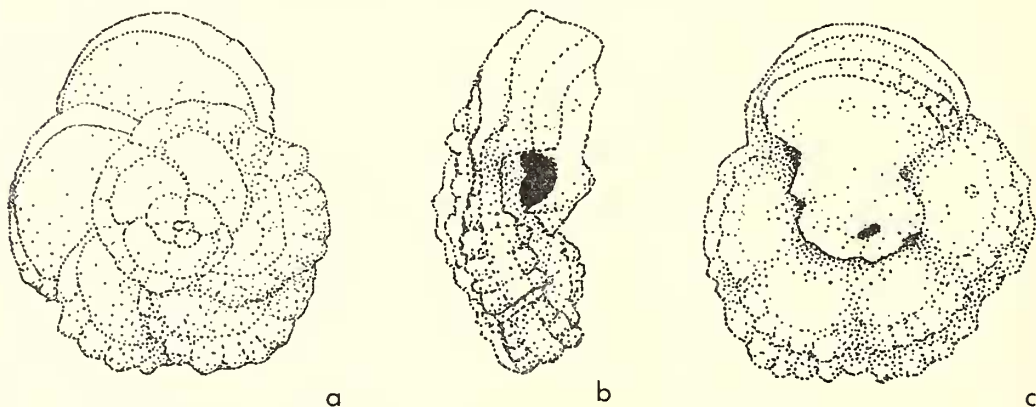
Family GLOBOTRUNCANIDAE Brotzen 1942

Genus ABATHOMPHALUS Bolli, Loeblich, and Tappan 1957

Abathomphalus mayaroensis (Bolli)

Plate 2, figs. 5-7; text-fig. 9

- 1951 *Globotruncana mayaroensis* Bolli, p. 198, pl. 35, figs. 10-12.
 ? 1953 *Globotruncana mayaroensis* Bolli; Subbotina, p. 181, pl. 8, figs. 2a-c.
 1955 *Rugotruncana mayaroensis* (Bolli); Brönnimann and Brown, pp. 553-4, pl. 22, figs. 10-12.
 1957 *Abathomphalus mayaroensis* (Bolli); Bolli, Loeblich, and Tappan, p. 43, pl. 11, figs. 1a-c.
 1957 *Abathomphalus mayaroensis* (Bolli); Bolli, p. 54, text-fig. 10.
 1957 *Globotruncana (Globotruncana) planata* Edgell, p. 115, pl. 4, figs. 7-9.



TEXT-FIG. 9. *Abathomphalus mayaroensis* (Bolli), (a) dorsal, (b) edge, and (c) ventral views; No. 1177, $\times 100$.

Description. In the specimens examined the test is trochospiral, concavo-convex, with two widely separated keels and a tegillum covering the umbilicus. In spiral view the periphery is lobed. About 12-14 chambers are arranged in 3 whorls with 4-5 chambers in the last whorl. The spiral and radial sutures are arcuate, thick, raised, and beaded. The surface of the chambers is generally smooth and finely perforate. In umbilical view the

radial sutures are straight and unthickened. The chambers are slightly inflated and slope rather steeply towards the narrow umbilicus; their surfaces have a granular and finely porous appearance. The primary aperture is extra-umbilical. A delicate tegillum extends across the umbilicus from the margin of the last chamber, and is provided with accessory intralaminar apertures. In peripheral view the two strongly beaded keels are separated by a wide band of granular appearance.

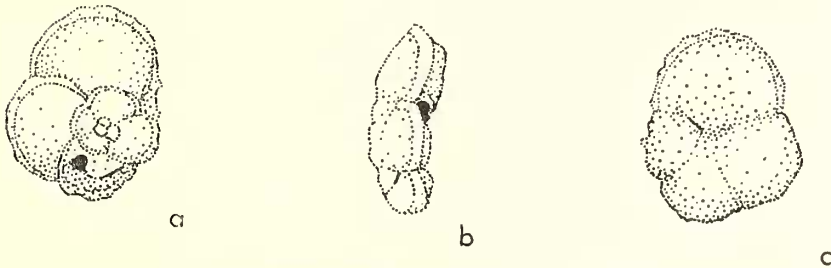
Stratigraphical distribution. Generally regarded as characteristic of, and confined to, the uppermost Maestrichtian.

Geographical distribution. Ranges from approximately 57° N. (Kjölby Gaard, Denmark; Berggren 1960) to 22° S. (NW. Australia; Edgell 1957). It has also been recorded from the western side of the Gulf of Mexico (Hay 1960), Trinidad (Bolli 1951), the Pyrenees (Mangin 1960), and the circum-Mediterranean area generally as far as the eastern side of the Black Sea (Subbotina 1953) and Madagascar (Lys 1960). Though regarded by Olsson (1964) as a Tethyan form (it does not occur in New Jersey, U.S.A.) it was clearly wide-ranging at least as occasional examples.

Abathomphalus intermedia (Bolli)

Plate 2, figs. 8–10; text-fig. 10

- 1951 *Globotruncana intermedia* Bolli, p. 197, pl. 35, figs. 7–9.
- 1955 *Rugotruncana intermedia* (Bolli); Brönnimann and Brown, p. 553, pl. 22, figs. 13–15.
- 1956b *Marginotruncana intermedia* (Bolli); Hofker, p. 75, pl. 10, figs. 74a–c.
- ? 1957 *Abathomphalus intermedia* (Bolli); Bolli, p. 54, no fig.
- ? 1960 *Abathomphalus intermedia* (Bolli); Bolli and Cita, pp. 153, 154, no fig.
- 1962 *Praeglobotruncana (Praeglobotruncana) intermedia* (Bolli); Berggren, p. 31, pl. 7, figs. 2a–c.



TEXT-FIG. 10. *Abathomphalus intermedia* (Bolli), (a) dorsal, (b) edge, and (c) ventral views; No. 1178, × 100.

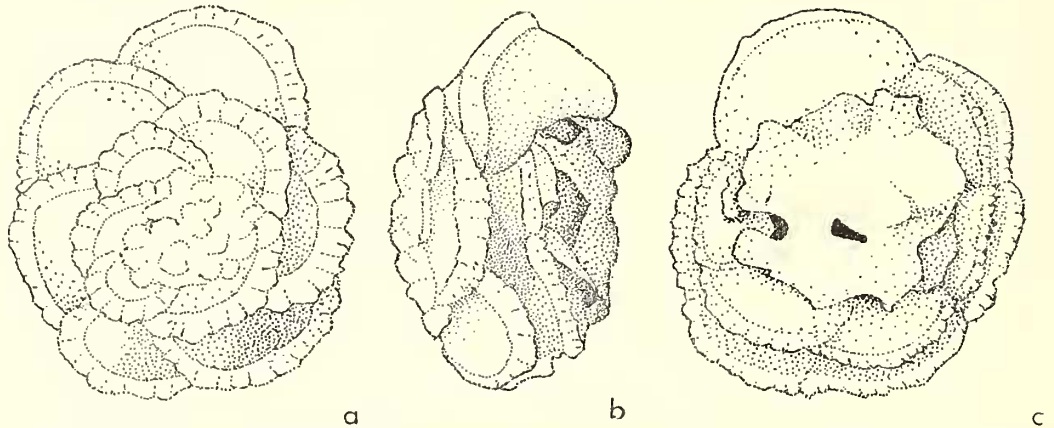
Description. In the specimens examined the test is trochospiral concavo-convex with two delicate keels separated by a granular area. In dorsal view the periphery is lobed. Approximately 8–9 chambers are arranged in 3 whorls with 3–4 chambers in the last whorl. The spiral and radial sutures are arcuate, thickened but not raised. The chamber surfaces are smooth and finely perforate. On the ventral surface the chambers are weakly inflated, the radial sutures are thickened and slightly depressed. The primary aperture is extra-umbilical; a delicate tegillum which extends across the umbilicus from the margin of the last chamber is provided with at least 3 intralaminar apertures.

Stratigraphical distribution. Middle to upper Maestrichtian (El-Naggar 1966).

Geographical distribution. The species ranges from approximately 57° N. (Kjölby Gaard, Denmark; Berggren 1962) to 10° N. (Trinidad; Bolli 1951). It has also been recorded from Mexico, Colombia (Gandolfi 1955), Cuba (Brönnimann and Brown 1955), NW. Germany and Holland (Hofker 1956b), and from the Nile Valley (El-Naggar 1966).

Genus *GLOBOTRUNCANA* Cushman 1927*Globotruncana arca* (Cushman)

Plate 2, figs. 11–13; Plate 3, figs. 1–3; text-fig. 11

1926 *Pulvinulina arca* Cushman, p. 23, pl. 3, fig. 1.1927b *Globotruncana arca* (Cushman); Cushman, p. 91, pl. 19, figs. 11a–c.1960 *Globotruncana leupoldi* Bolli; Olsson, p. 50, pl. 11, figs. 1–3.

TEXT-FIG. 11. *Globotruncana arca* (Cushman), (a) dorsal, (b) edge, and (c) ventral views; No. 1167, $\times 100$.

Descriptions. In the specimens examined the test is trochospiral, biconvex, with the strongest convexity on the spiral surface. On the spiral surface 14–19 chambers are arranged in 3–4 whorls, with 5–7 chambers in the final whorl. Both spiral and radial sutures are arcuate, thickened, raised, and beaded; on some specimens granules developed on the apex of the spire obscure the early chambers. The chamber surfaces are planar, sometimes concave, generally smooth and finely porous. The radial sutures of the umbilical surface are thickened and beaded; the thickening extends around the umbilical edge of each chamber. Chamber surfaces are smooth, sometimes granular, finely porous. The wide umbilicus is sometimes covered by a non-porous plate; the primary aperture is intra-umbilical; both it and relict apertures of preceding chambers open into the umbilicus. Apertures associated with the umbilical plate are both infra- and intralaminar. The lobed peripheral margin is bordered by two keels which are separated by a wide granular area.

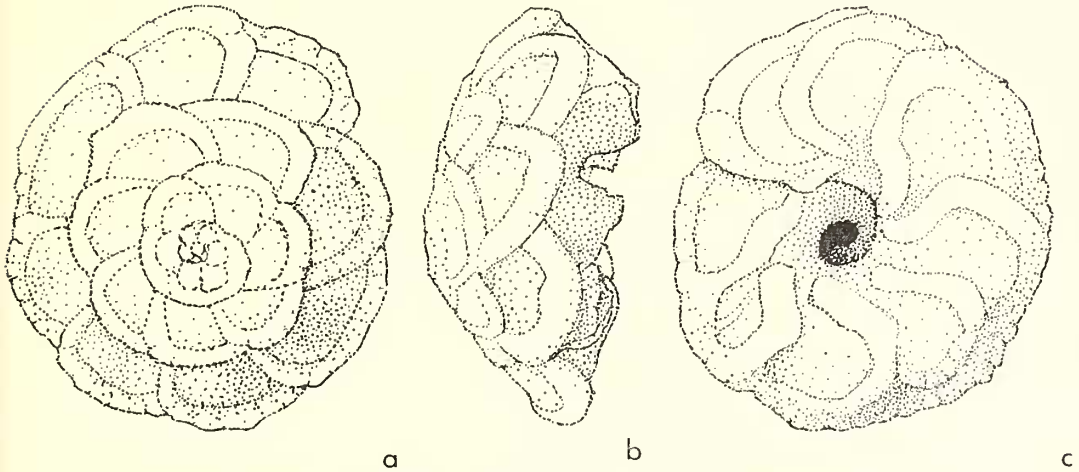
Stratigraphical distribution. Mainly Maestrichtian, but has also been recorded from the upper Campanian (Ksiazkiewicz 1956).

Geographical distribution. *G. arca* is apparently cosmopolitan; it ranges from approximately 57° N. (Kjølby Gaard, Denmark; Berggren 1960) to 22° S. (NW. Australia; Edgell 1957). Within these latitudes it is recorded from the Pacific (Hamilton 1953), Vancouver (McGugan 1964), on the west coast (Douglas and Sliter 1966), Gulf (Cushman 1946), and east coast (Olsson 1960) of North America, Mexico (Hay 1960), Cuba, Trinidad (Bolli 1951), northern Europe, the circum-Mediterranean area, the Caucasus (Subbotina 1953), and West Pakistan (Nagappa 1960).

Globotruncana conica White

Plate 3, fig. 4-6; text-fig. 12

- 1928 *Globotruncana conica* White, p. 285, pl. 38, fig. 7.
 1955 *Globotruncana stuarti conica* (White); Gandolfi, p. 65, pl. 5, fig. 8.
 1956 *Globotruncana* cf. *conica* White; Ksiaskiewicz, p. 283, fig. 61.



TEXT-FIG. 12. *Globotruncana conica* White, (a) dorsal, (b) edge, and (c) ventral views; No. 1170, $\times 100$.

Description. In the specimens examined the test is spiroconvex; its umbilical side is obtusely conical and truncated. On the spiral surface 27 chambers are arranged in 4 whorls with 8 chambers in the last. The chambers increase rapidly in size in the first 2 whorls, less so in the third, and are approximately equal in the fourth; they are triangular in the early whorls, quadrangular in the last. Both spiral and radial sutures are thickened, raised, and beaded; beading is pronounced on the last whorl. On the umbilical surface the radial sutures are thickened, weakly beaded, and extend on to the umbilical edges of the chambers. The primary and relict apertures of preceding chambers open into the umbilicus. The circular periphery is characterized by a single prominent keel with traces of a second.

Stratigraphical distribution. Santonian to upper Maestrichtian (Cita 1948, Douglas and Sliter 1966).

Geographical distribution. *G. conica* is widely distributed in the northern hemisphere where it ranges from approximately 50° N. (Bachowice, Poland; Ksiaskiewicz 1956) to 11° N. (NE. Colombia; Gandolfi 1955). Between these latitudes it is recorded from the west coast of N. America (Douglas and Sliter 1966), Tampico, Mexico (Hay 1960), Trinidad (Bolli 1951), Puerto Rico (Pessagno 1960), Tunisia (Dalbiez 1955), and the circum-Mediterranean area as far as the Sinai Peninsula (Said and Kenawy 1956).

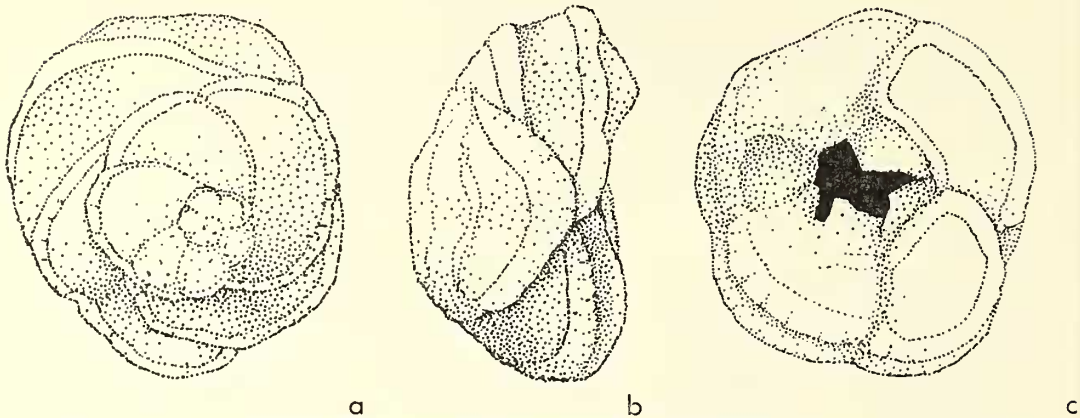
Globotruncana contusa (Cushman)

Plate 3, figs. 7-9; text-fig. 13

- ? 1926 *Pulvinulina arca* var. *contusa* Cushman, p. 23, no fig.
 1966 *Globotruncana fornicata* Plummer; Douglas and Sliter, pp. 110-11, pl. 2, figs. 2, 4 (*non* figs. 1, 3).

1966 *Globotruncana contusa patelliformis* Gandolfi; El-Naggar, pl. 8, figs. 1a-c.

1966 *Marginotruncana contusa* (Cushman); Hofker, p. 95, pl. 17, fig. 78.



TEXT-FIG. 13. *Globotruncana contusa* (Cushman), (a) dorsal, (b) edge, and (c) ventral views; No. 1169, $\times 100$.

Description. In the specimens examined the test is trochospiral, slightly lobed, strongly spiroconvex with a deep umbilicus. Its spiral surface contains 13–19 chambers arranged in three whorls with 4–7 in the last. The chambers, which are initially circular and inflated, become triangular and flat and finally crescentic with undulating surfaces. The sutures are thick and beaded, the chamber surfaces finely porous. On the umbilical side the chamber surfaces are coarsely papillate and porous, and the thickened, beaded radial sutures extend around the umbilical edges of the chamber. The primary and relict apertures open into the umbilicus; associated apertural portici are present on some specimens. Two closely spaced carinae are developed on the umbilical side of the peripheral surface.

Stratigraphical distribution. Probably exclusively Maestrichtian, though the species has been recorded in the upper Campanian of Poland (Bieda 1958).

Geographical distribution. The species is widely distributed. It ranges from approximately 57° N. (Kjölby Gaard, Denmark; Hofker 1960) to 22° S. (NW. Australia; Edgell 1957). It is also recorded from the west coast of North America (Douglas and Sliter 1966), and New Jersey (Olsson 1960), Tampico embayment, Mexico (Hay 1960), Trinidad (Bolli 1951), northern Europe, the circum-Mediterranean area, and West Pakistan (Nagappa 1960).

Globotruncana falsostuarti Sigal

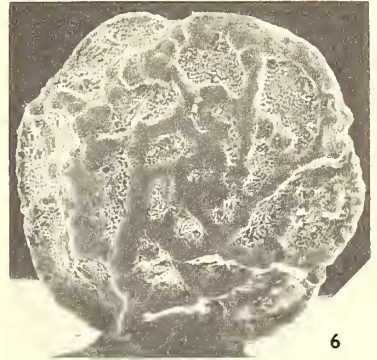
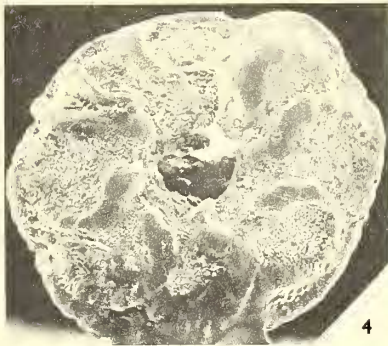
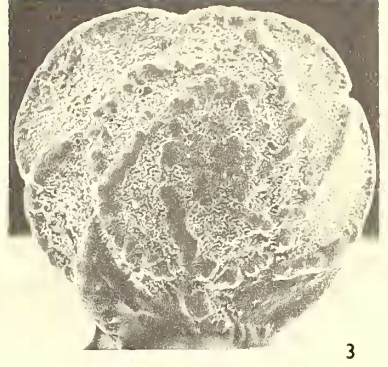
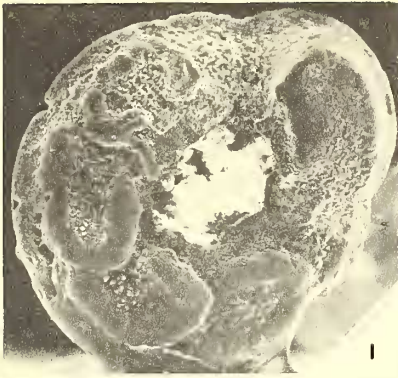
Plate 3, figs. 10–12; text-fig. 14

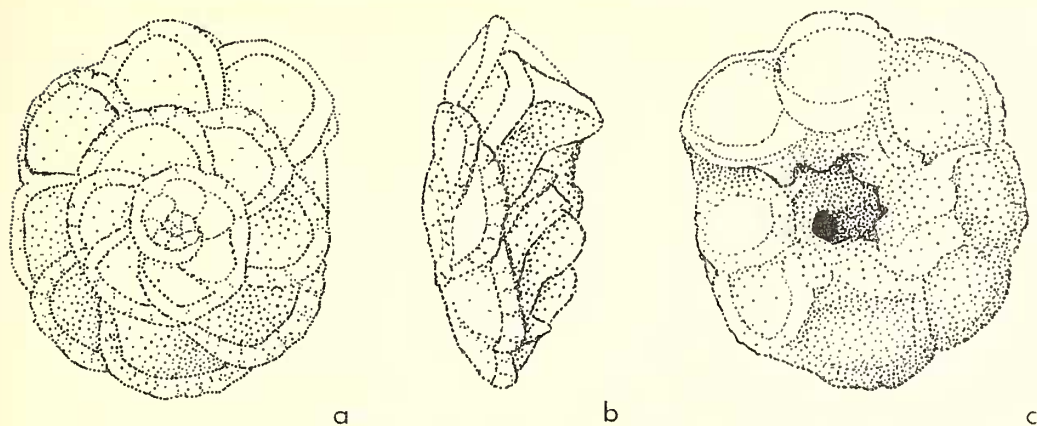
1951 *Globotruncana conica* White; Bolli, p. 196, pl. 34, figs. 13–15.

1952 *Globotruncana falsostuarti* Sigal, p. 43, fig. 46.

EXPLANATION OF PLATE 3

Figs. 1–12. *Globotruncana* spp. 1–3, *G. arca* (Cushman), ventral, edge, and dorsal views; No. 1168, $\times 71$. 4–6, *G. conica* White, ventral, edge, and dorsal views; No. 1170, $\times 71$. 7–9, *G. contusa* (Cushman), ventral, edge, and dorsal views; No. 1169, $\times 71$. 10–12, *G. falsostuarti* Sigal, ventral, edge, and dorsal views; No. 1173, $\times 70$.





TEXT-FIG. 14. *Globotruncana falsostnarti* Sigal, (a) dorsal, (b) edge, and (c) ventral views; No. 1173, $\times 100$.

Description. In the specimens examined the test is trochospiral, circular, weakly lobed, and biconvex. Its spiral surface contains 25 chambers arranged in $3\frac{1}{2}$ whorls with 7–8 approximately equal chambers in the last. Sutures are thick, raised, and beaded. The chamber surfaces are smooth and finely porous on both sides of the test; on the umbilical side the thickened radial sutures extend around the umbilical edge of the chambers. Both primary and relict apertures open into the wide umbilicus; their associated portici extend obliquely into the umbilicus. Traces of a tegillum are preserved on some specimens. A single prominent keel and weak traces of a closely separated second keel on the final chambers, are present on the peripheral surface.

Stratigraphical range. Campanian to upper Maestrichtian (Bolli 1951).

Geographical distribution. Records of this species are confined to the northern hemisphere. It has been reported from Trinidad (Bolli 1951), Southern Limburg (Hofker 1966), Upper Bavaria (Knipscheer 1956), Morocco (Lehmann 1966), Algeria (Sigal 1952), and Tunisia (Dalbiez 1955).

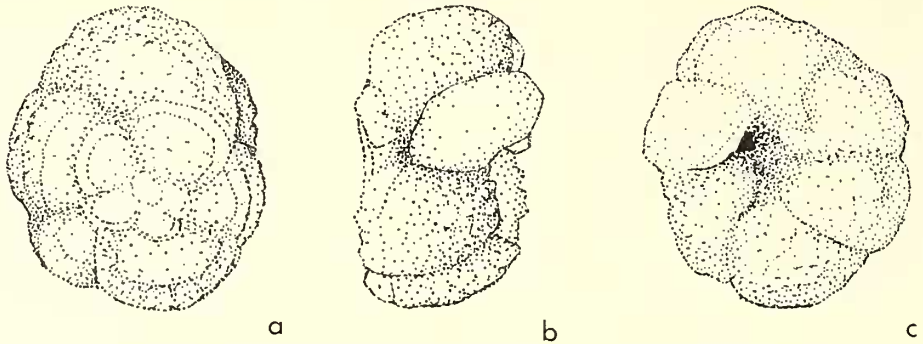
Globotruncana gansseri Bolli

Plate 4, figs. 1–3; text-fig. 15

- ? 1950 *Globotruncana gansseri* Bolli, p. 87, no fig.
- 1951 *Globotruncana gansseri* Bolli; Bolli, p. 196, pl. 35, figs. 1–3.
- 1957 *Globotruncana (Globotruncana) lugeoni* Tilev; Edgell, p. 113, pl. 2, figs. 7–9.
- 1960 *Globotruncana monmouthensis* Olsson, p. 50, pl. 10, figs. 22–24.

Description. In the specimens examined the test is trochospiral, umbilical-convex, with a lobed periphery. On its spiral surface 15 chambers are contained in $2\frac{1}{2}$ whorls with 5–6 chambers in the last. Initially inflated, they are followed by chambers whose surfaces slopes towards the spiral apex. The sutures are curved, raised, and beaded, the chamber surfaces smooth and finely porous, weakly papillose on the final whorl. Ventrally the chambers are coarsely papillose, the papillae becoming scattered on the last chamber; the sutures are radial and depressed. Both the primary and relict apertures open into

the umbilicus; the primary has a delicate porticus. A single heavily beaded keel is developed on the peripheral surface.



TEXT-FIG. 15. *Globotruncana gausseri* Bolli, (a) dorsal, (b) edge, and (c) ventral views; No. 1175, $\times 100$.

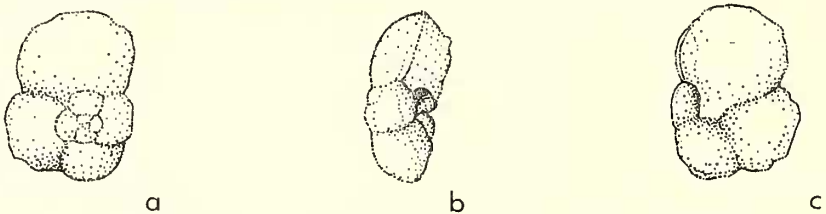
Stratigraphical distribution. Lower to upper Maestrichtian (Wille-Janoschek 1966).

Geographical distribution. A widely distributed species which ranges from approximately 57° N. (Kjölby Gaard, Denmark; Berggren 1962) to 22° S. (NW. Australia, Edgell 1957). Between these latitudes it is reported from the Pacific (Hamilton 1953), the West Coast and New Jersey (North America; Douglas and Sliter 1966, Olsson 1960), Mexico (Olvera 1959), the Caribbean area, the North Atlantic (Saito *et al.* 1966), Northern Europe, the circum-Mediterranean area, and Madagascar (Lys 1960).

Globotruncana havanensis Voorwijk

Plate 4, figs. 4-6; text-fig. 16

- 1937 *Globotruncana havanensis* Voorwijk, pp. 195, 197, pl. 1, figs. 25, 26, 29.
 1951 *Globotruncana citae* Bolli, p. 197, pl. 35, figs. 4-6.
 1955 *Rugotruncana havanensis* (Voorwijk); Brönnimann and Brown, p. 552, pl. 22, figs. 4-6; pl. 24, figs. 5, 10.
 1955 *Globotruncana citae* Bolli; Gandolfi, p. 51, pl. 3, fig. 11.
 1956b *Marginotruncana citae* (Bolli); Hofker, pp. 76, 79, fig. 72.
 1957 *Globotruncana (Globotruncana) citae* Bolli; Edgell, p. 111, pl. 1, figs. 13-15.
 1959 *Globotruncanella havanensis* (Voorwijk); Olvera, pp. 94-6, pl. 4, figs. 12, 13, 14.
 ? 1960 *Praeglobotruncana havanensis* (Voorwijk); Berggren, pp. 185, 190, no fig.
 1960 *Rugoglobigerina jerseyensis* Olsson, p. 49, pl. 10, figs. 19-21.
 1960 *Globotruncana citae* Bolli; Hofker, pp. 217, 225, 231, 234, 235, fig. 20.



TEXT-FIG. 16. *Globotruncana havanensis* Voorwijk, (a) dorsal, (b) edge, and (c) ventral views; No. 1176, $\times 100$.

Description. In the specimens examined the test is trochospiral, spiroconvex, ventrally flat or weakly concave. On the spiral surface 9 weakly inflated chambers are arranged

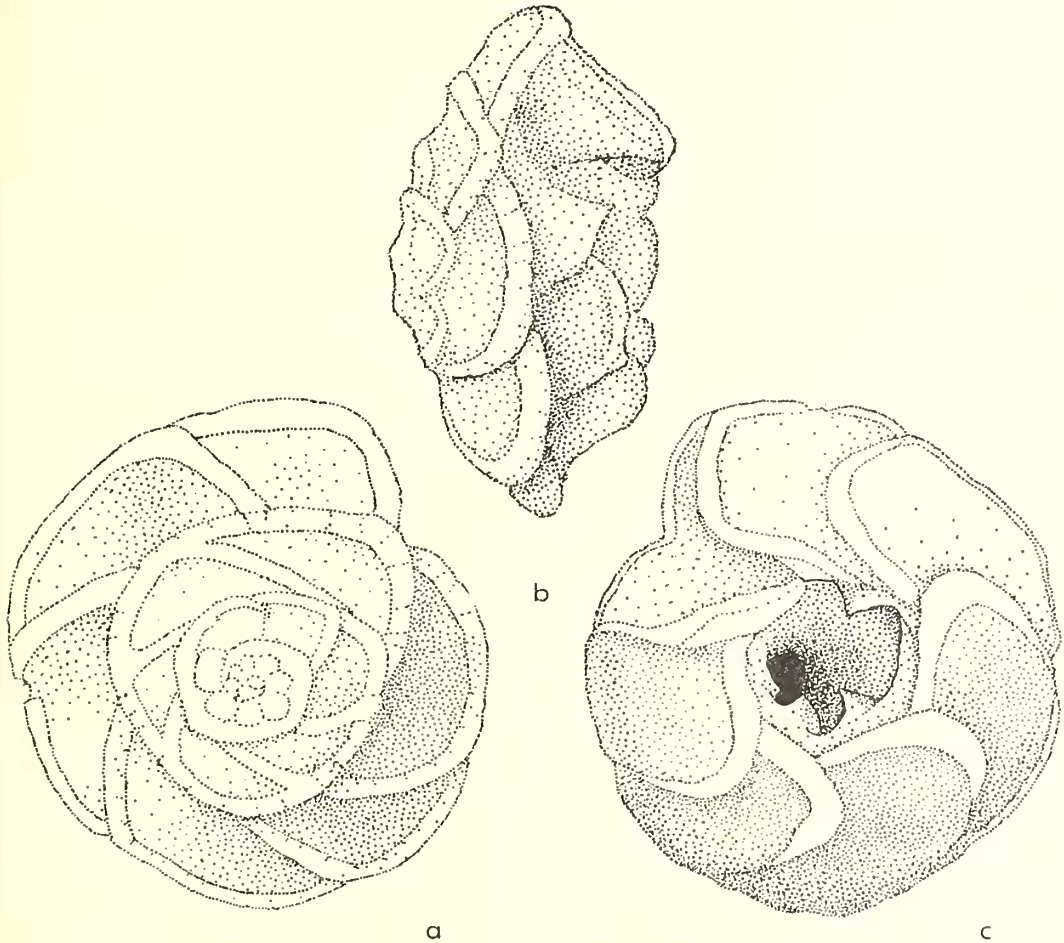
in approximately 2 whorls with 4 chambers in the last. The sutures are arcuate depressed, on the ventral surface radial depressed; the chamber surfaces are smooth and porous. The aperture is intra-umbilical, bordered by a porticus which extends towards the umbilicus. A single weakly developed keel is present on the peripheral surface.

Stratigraphical distribution. Recorded mainly from the Maestrichtian though it is also reported from the Campanian of Trinidad (Bolli 1957).

Geographical distribution. *G. havanensis* ranges from approximately 57° N. (Kjølby Gaard, Denmark; Hofker 1960) to 22° S. (NW. Australia; Edgell 1957). Within these latitudes it is recorded from the West Coast of North America (Douglas and Sliter 1966), Tampico embayment, Mexico (Olvera 1959), NE. Colombia (Gandolfi 1955), Cuba (Brönnimann and Brown 1955), Trinidad (Bolli 1951), northern Europe, and the circum-Mediterranean region as far east as Scotchi on the north-east shores of the Black Sea (Subbotina 1953).

Globotruncana stuarti (de Lapparent)

Plate 4, figs. 7-9; text-fig. 17



TEXT-FIG. 17. *Globotruncana stuarti* (de Lapparent), (a) dorsal, (b) edge, and (c) ventral views; No. 1171, $\times 100$.

- 1918 *Rosalina stuarti* de Lapparent, pp. 11, 12, pl. 12, fig. 4, pl. 13, fig. 5a-c.
 1936 *Globotruncana stuarti* (de Lapparent); Renz, pp. 19, 20, pl. 6, figs. 35-41; pl. 8, fig. 6.
 1962 *Globotruncana (Globotruncana) stuarti stuarti* Pessagno, chart 2, pl. 2, figs. 1-3.

Description. In the specimens examined the test is trochospiral, almost biconvex; its periphery is circular and entire. On the spiral surface 12-26 chambers are contained in $2\frac{1}{2}$ - $3\frac{1}{2}$ whorls, with 4-7 in the last; the initially circular chambers are followed by triangular and finally quadrangular chambers. The sutures are thickened, raised, beaded; ventrally the radial sutures extend on to the umbilical edge of each chamber. Chamber surfaces are smooth and finely porous. Both primary and secondary apertures open into the umbilicus; delicate asymmetrical triangular portici extend obliquely into the umbilicus from each chamber. A single prominent keel is developed on the peripheral surface.

Stratigraphical distribution. Upper Campanian to upper Maestrichtian (Bolli 1951).

Geographical distribution. A widely distributed species, ranging from approximately 57° N. (Kjölby Gaard, Denmark; Berggren 1962) to 16° S. (Madagascar; Lys 1960). It is also recorded from Trinidad (Bolli 1951), Puerto Rico (Pessagno 1962), W. Nigeria (Reyment 1960), northern Europe, the circum-Mediterranean region, and Pakistan (Nagappa 1959).

Globotruncana stuarti stuartiformis Dalbiez

Plate 4, figs. 10-12; text-fig. 18

- 1951 *Globotruncana stuarti* de Lapparent; Tilev, pp. 34-41, pl. 1, figs. 1, 4 (*non* 3); text-figs. 7, 8 (*non* 9).
 1955 *Globotruncana (Globotruncana) elevata stuartiformis* Dalbiez, p. 169, text-fig. 10.
 1961 *Globotruncana elevata stuartiformis* Dalbiez; Scheibnerova, p. 70, pl. 13, fig. 1.
 1962 *Globotruncana (Globotruncana) stuarti stuartiformis* Dalbiez; Pessagno, p. 362, pl. 2, figs. 4-6.
 1966 *Globotruncana elevata stuartiformis* Dalbiez; Wille-Janoschek, pp. 103-5, 147, 148, 149, 150, pl. 7, figs. 6-8, taf. 9.

Description. In the specimens examined the test is trochospiral, biconvex, with a weakly lobed periphery. On its spiral surface 19-22 chambers are arranged in $3-3\frac{1}{2}$ whorls with 5-6 in the last; chambers are triangular but the final 2 or 3 are quadrangular. Both spiral and radial sutures are raised, thick, and beaded; ventrally the thickened radial sutures extend around the umbilical edges of the chambers. The chamber surfaces are smooth and finely porous. Both the primary and relict apertures open into the umbilicus; delicate portici which extend obliquely into the umbilicus are sometimes preserved. The peripheral surface is unicarinate.

Stratigraphical distribution. Upper Campanian to upper Maestrichtian (Wille-Janoschek 1966).

Geographical distribution. *G. stuarti stuartiformis* is so far unrecorded from the southern hemisphere; it ranges from approximately 49° N. (W. Carpathians; Scheibnerova 1961) to 18° N. (Puerto Rico;

EXPLANATION OF PLATE 4

Figs. 1-12. *Globotruncana* spp. 1-3, *G. gausseri* Bolli, ventral, edge, and dorsal views; No. 1175, $\times 85$. 4-6, *G. havanensis* Voorwijk, ventral, edge, and dorsal views; No. 1176, $\times 170$. 7-9, *G. stuarti* (de Lapparent), ventral, edge, and dorsal views; No. 1171, $\times 59$. 10-12, *G. stuarti stuartiformis* Dalbiez, ventral, edge, and dorsal views; No. 1172, $\times 59$.

